Phenotypic characterization of draft donkeys within the Sudano-Sahelian zone of Cameroon

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Key words

Donkey - Draft animal - Body conformation - Body measurement - Sudano-Sahelian region - Cameroon.

Summary

Data on age, sex, coat color, liveweight (LW), heart girth (HG), trunk length (TL) and height-at-withers (HW) for 743 donkeys within the Sudano-Sahelian region of Cameroon were recorded. The ages of the donkeys ranged from 0 to 13 years. The effect of age on liveweight, height-at-withers, heart girth and trunk length was highly significant ($p < 0.001$). The effect of coat color on liveweight and height-at-withers was not significant ($p > 0.05$). Male donkeys were generally heavier than female donkeys from 0 to 3 years of age. Thereafter, female donkeys became heavier than males ($p < 0.002$). The average liveweights of adult (6-13 years old) female and male donkeys (132.5 ± 2.3 and 123.2 ± 2.1 kg, respectively) may not have had any significant practical implications on the working capacity of the sexes, given that non visible pregnant female donkeys might have been included in the study. As a result, regression equations established for the estimation of liveweight were not gender discriminative. Consequently, the best prediction equations for donkeys' liveweights within the Sudano-Sahelian region were:

■ $LW = HG^{2.826}/4434.7$ (adjusted $R^2 = 0.84$) for one best fit variable with LW in kilograms and HG in centimeters. When trunk length, or height-at-withers, was considered for one best fit variable in the equation, the adjusted R^2 values were 0.78 and 0.66, respectively;

■ $LW = HG^{1.947}.TL^{0.845}/3834.8$ (adjusted $R^2 = 0.86$) for two best fit variables with TL in centimeters. The inclusion of HW as a third variable in the equation did not modify R^2 significantly.

■ INTRODUCTION

Cameroon will continue to rely on draft animal power as a substitute for agricultural mechanization, especially with the devaluation of the Cameroon currency, the franc CFA, and the persistent economic recession. Emphasis had been on the use of oxen for draft activities, but today donkeys are used increasingly especially within the cotton producing zone. From 1978 to 1983 the donkey population rose from 700 to 3000 (9). In 1997 this number had risen to approximately 21,000 (7). This can be attributed to their low cost and their ability to tolerate dry conditions, live on poor feed rejected by other classes of livestock as well as survive in tsetse infested areas (4). Diseases such as rinderpest and foot and mouth, common in cattle, do not affect donkeys, making them an important replacement energy source (1).

Tembo (11) and Vall (12) suggested that draft capacity is directly proportionate to body size. Vall (12) reported that the donkey has an optimal draft force between 10 and 16% of its liveweight with the animal working between 3 and 6 h at a speed of 0.7 to 0.9 m/s. Jones (2) estimated the optimal draft force of a donkey between 16 and 20% of its liveweight at a speed of 0.7 to 1.1 m/s for 3 to 3.5 h a day. Within the Sudano-Sahelian zone of Cameroon, however, the characteristic small donkeys are at times used when too young or too old for draft activities, and the above suggested work output is not achieved. Breeding practices are also uncontrolled, resulting in animals with poor conformation. The purpose of this paper was to evaluate liveweight and some linear body weight traits, useful in the assessment of draft performance. It also aimed at defining the relationships between liveweight and the different linear body measurements. Some of the factors that affect these relations were examined.

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■ MATERIALS AND METHODS

Animals

The study population was composed of 743 healthy donkeys of which 422 were males and 321 females. They were randomly measured from a donkey population of approximately 15,000 (7). Visibly pregnant females were excluded from the study. Their ages ranged from 0 to 13 years and their coat colors varied from shades of grey, black or cream.

Animal management

During the dry season the animals usually fended for themselves on open natural pastures, with little or no health care. During the farming period (rainy season), they were brought back to graze around the houses and a little health attention was given to them. Varying amounts of sorghum grains and cotton seed cake were given as feed supplements. Water was usually available at all times.

Study location

The study was carried out during the cold dry season (October to January) of 1994, 1995 and 1996. Three major cotton producing regions (figure 1) with about 83% of draft donkeys in the Sudano-Sahelian region of Cameroon were involved. The regions included Guider (368 donkeys measured) at a latitude of 09° 53' N and a longitude of 13° 17' E in the North Province, Maroua South (189 donkeys measured) at a latitude of 10° 35' N and a longitude of 14° 20' E and Kaele (186 donkeys measured) at a latitude of 10° 06' N and a longitude of 14° 27' E in the Far North Province.

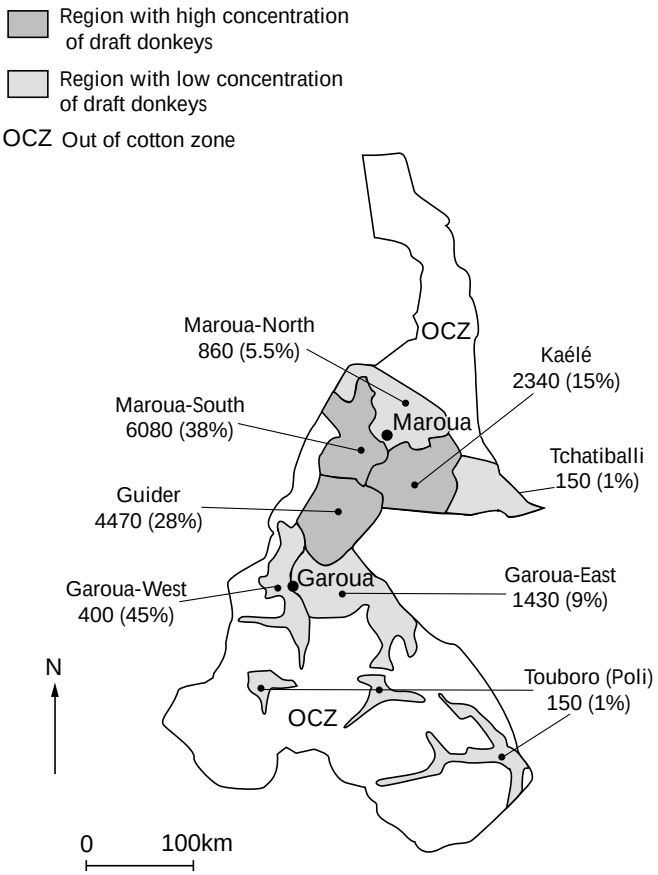

***Figure 1**: Distribution of draft donkeys in North Cameroon, according to SODECOTON, Garoua, Cameroon (May 1997-October 1997 report).*

Choice of conformation traits

Traits chosen for the study were those which could be measured easily: liveweight (LW), using a mobile electronic balance (Marechalle Pesage) and a mobile weighing cage; heart girth (HG or circumference of the chest) and trunk length (TL or length from the olecranon process of the elbow to the *tuber ischiadicum*), using a graduated plastic tape; and height-at-withers (HW or the height from the highest point of the dorsum of the donkey to the ground surface at the level of the front leg), using a measuring stick. Coat color and sex were recorded and ages were determined from the incisors according to Jones (2). Measurements were usually carried out very early in the morning before the donkeys were sent out to graze to avoid inflated measurements as a result of feeding. The data were classified based on age, sex, coat color, year of measurement and region.

Statistical analysis

Two fixed models were used to estimate the least squares means (LSM) for the liveweight, heart girth, trunk length and height-at-withers and best fit variables for multiple regression equations for estimation of liveweight. All factors in the models were considered fixed, but for the random error that was assumed to be identically, independently and normally distributed with zero means and variance σ^2 (iind 0 , σ^2).

Estimation of least squares means for conformation characters

$$Y_{ijkl} = \mu + A_i + S_j + (AS)_{ij} + C_k + e_{ijkl}$$

μ the overall mean of a given response trait;
Y the response growth trait (LW, HW, HG, TL);
A_i fixed effect of age;
S_j fixed effect of sex;
$(AS)_{ij}$ fixed effect of the interaction between age and sex;
C_k fixed effect of coat color;
and e_{ijkl} random error attributable to the l^{th} donkey with the k^{th} coat color, of sex j and of age i.

Estimation of best fit variables for multiple regression

Plots of liveweights against individual measurements for heart girth, trunk length and height-at-withers were made to test for linearity and were found to be curvilinear. The measured values were transformed into logarithms and the plots became intrinsically linear with significant improvements in fits obtained as reflected in the R^2 values (figure 2). From these transformations, simple linear regression equations were established for each of the three linear measurements and multiple linear equations also established for a two and a three best fit variables. The generalized multiple linear regression model adopted for the three factor variables was:

$$Log(LW)_{mnop} = a + b.Log(HG)_m + c.Log(TL)_n + d.Log(HW)_o + e_{mnop}$$

LW is the liveweight estimated in Log from the phenotypic values of HG, TL and HW in Log, a the intercept, b partial regression coefficient of LW on the m^{th} phenotypic value of HG, c partial regression coefficient of LW on the n^{th} phenotypic value of TL,

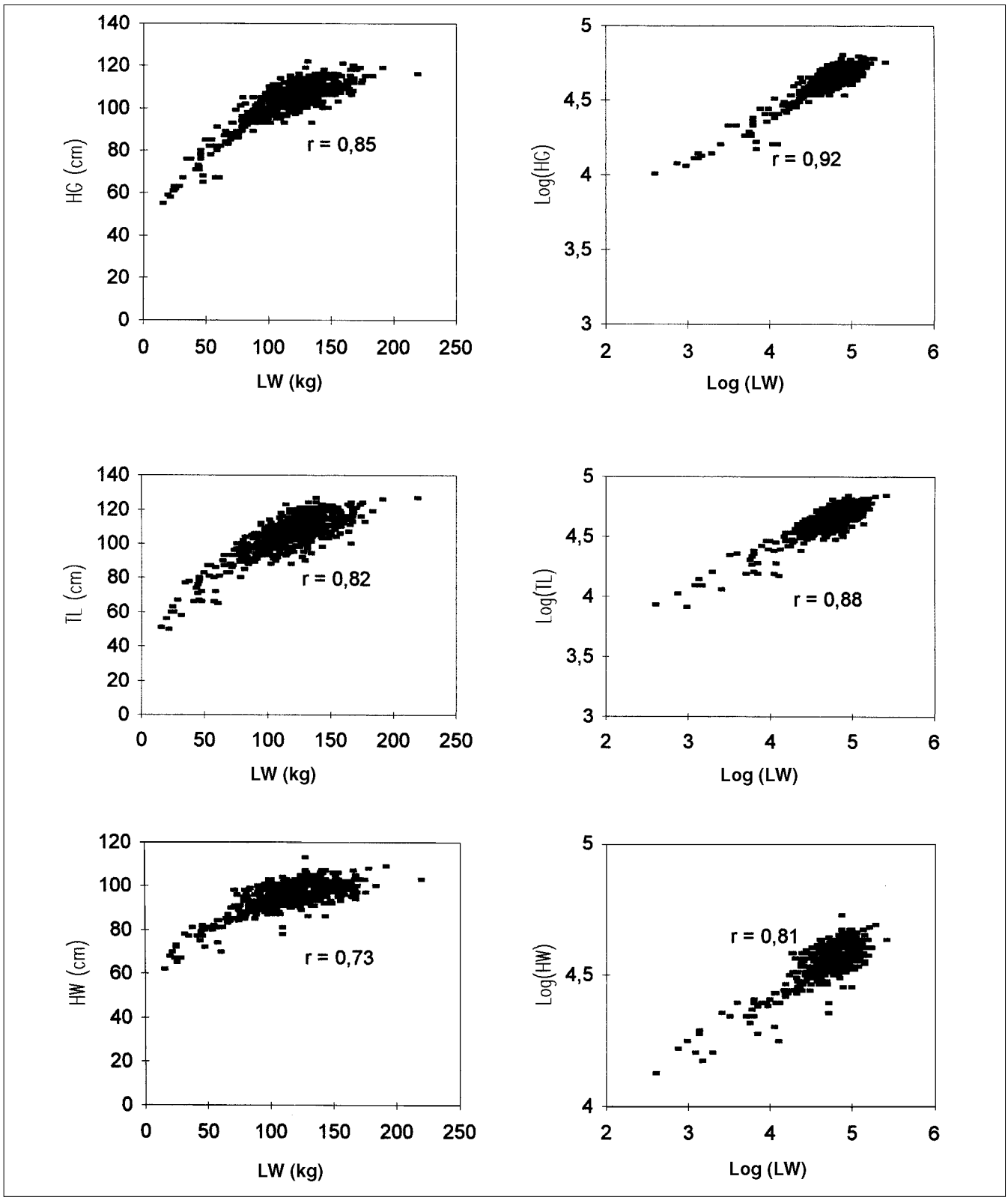

***Figure 2**: Relationships between liveweight (LW in kilograms) and heart girth (HG in centimeters); LW and trunk length (TL in centimeters); LW and height-at-withers (HW in centimeters). Real and Log values.*

d partial regression coefficient of LW on the o^{th} value of HW and e_{mnop} residual error attributable to individual p. Final results were those with the best R^2. Liveweight was then estimated as:

$LW = HG^b.e^a$; for a one best fit predictor equation;
$LW = HG^b.TL^c.e^a$; for a two best fit predictor equation.

The data were analyzed using the SAS computer program (10). This program adjusted for significant fixed factors. The least squares means and standard errors of the various traits were computed using this program. Multiple regression analyses were carried out by use of the stepwise procedure to obtain the best fit variables that could be included in regression equations.

■ RESULTS

The effects of year and region of measurement on liveweight, heart girth, trunk length and height-at-withers were tested and found not significant ($p > 0.05$) and were therefore excluded from the model for estimation of least squares means.

Coat color

The distribution of the coat color phenotype (table I) showed that 94% of the donkeys had various shades of grey, 4% black and 2% cream. Liveweight and height-at-withers were not affected by coat color phenotype ($p > 0.05$) (table II). Coat color, however, affected trunk length and heart girth ($p < 0.05$).

Table I

Frequency distribution of coat color phenotype in draft donkeys in the Sudano-Sahelian zone of Cameroon

Coat color	Number	Phenotype frequency
Light grey	397	0.53
Dark grey	241	0.32
Brownish grey	65	0.09
Black	28	0.04
Cream	12	0.02
Total	743	1.00

Table II

Variance analysis results for the various fixed effects on liveweight, heart girth, trunk length and height-at-withers for 743 donkeys

Trait	Source	DF	F value	p
Liveweight	Age	11	34.80	0.0001 ***
	Sex	1	6.76	0.0095 **
	Age*sex	11	1.84	0.0475 *
	Color	4	1.99	0.0945 NS
Heart girth	Age	11	42.33	0.0001 ***
	Sex	1	1.00	0.3172 NS
	Age*sex	11	1.06	0.3881 NS
	Color	4	5.03	0.0005 **
Trunk length	Age	11	32.58	0.0001 ***
	Sex	1	5.06	0.0248 *
	Age*sex	11	1.92	0.0392 *
	Color	4	2.53	0.0392 *
Height-at-withers	Age	11	28.50	0.0001 ***
	Sex	1	20.03	0.0001 ***
	Age*sex	11	2.92	0.0009**
	Color	4	0.86	0.4875 NS

NS = non significant ($p > 0.05$)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Age

Age had a highly significant ($p < 0.001$) impact on all the traits measured (table II). There was a consistent increase in liveweight for estimated ages from 1 to 8 years (table III). Thereafter, this pattern became inconsistent. Plotting liveweight against age group the consistency which was linear was more evident from 0 to 6 years of age (figure 3). Thereafter there was a decline in liveweight. The same pattern was evident with plots of heart girth and not with plots of height-at-withers against age class (figure 4). On the basis of the structure of the curve the sample population was partitioned as consisting of 186 with ages 1-3 years, 303 with ages 4-6 years and 254 with ages 6-13 years. For male and female donkeys, mean liveweight, heart girth, trunk length and height-at-withers for adult age (6-13 years) were 123.2 (standard error 2.1) and 132.5 (s.e. 2.3) kg, 107.8 (s.e. 0.7) and 108.3 (s.e. 0.7) cm, 109.2 (s.e. 0.8) and 111.9 (s.e. 0.9) cm, and 100.1 (s.e. 0.5) and 97.7 (s.e. 0.5) cm, respectively (table III).

Sex

Sex was significant on liveweight, trunk length and height-at-withers ($p < 0.05$). Male donkeys were generally heavier than females from 0 to 3 years of age. Thereafter, female donkeys became heavier ($p < 0.002$). This was not evident with animals 11 years of age (table III). This could be attributed to the small sample size as reflected by the high standard error.

Relationship between the conformation characters

The correlation between liveweight and the other traits ranged from 0.73 to 0.85 (figure 2). Using the stepwise procedure, heart girth gave the best fit one variable regression model for the estimation of liveweight as:

$LW = HG^{2.826}/4434.7$ with adjusted $R^2 = 0.84$.

Using this equation, a table of estimated values for liveweight from actual values of heart girth is presented in table IV.

Considering two best fit variables the equation obtained was:

$LW = HG^{1.947}.TL^{0.845}/3834.8$ with adjusted $R^2 = 0.86$.

Figure 5 shows the plot of estimated values of liveweight obtained using the last equation against actual values. This figure indicates that this equation may be more efficient for lighter donkeys than for heavier ones. This makes the equation more useful in the area of study given the very small size of the donkeys found there. Using this equation a simple normogram (figure 6) useful for rural farmers was designed.

When a third variable (HW) was included in the model there was no significant modification in the R^2 value. For practical reasons, therefore, only the one and two best fit linear regression equations were maintained for the estimation of donkey liveweights in the Sudano-Sahelian region of Cameroon.

■ DISCUSSION

Though coat color did not affect liveweight significantly, it could be useful in the description of the Cameroonian donkey breed. The coat color, predominantly made of shades of grey (94%) with a black band on the shoulder region and shades of white around the nostrils, the ventral regions and the inner portion of the legs matched the description of Raveneau and Daveze (8) for *Equus asinus nubicus* (or *Equus asinus africanus*). The name comes from Nubia, a region in the Northern part of Sudan. Similar

Table III

Least squares means and standard error (s.e.) for liveweight (LW), heart girth (HG), trunk length (TL), height-at-withers (HW) of draft donkeys by age and sex

Age[1]	Sex[2]	Number	LW kg (s.e.)	HG cm (s.e.)	TL cm (s.e.)	HW cm (s.e.)
1	1	17	75.2 (4.7)	91.1 (1.3)	89.2 (1.7)	90.1 (0.9)
1	2	16	72.0 (5.0)	89.9 (1.3)	90.8 (1.8)	86.2 (1.0)
2	1	23	94.9 (4.1)	99.3 (1.1)	100.8 (1.5)	95.2 (0.8)
2	2	21	90.7 (4.3)	96.9 (1.2)	99.1 (1.6)	91.5 (0.8)
3	1	56	105.0 (2.9)	101.2 (0.8)	102.3 (1.1)	94.9 (0.6)
3	2	53	111.2 (2.8)	103.4 (0.7)	105.0 (1.0)	95.1 (0.6)
4	1	70	110.7 (2.6)	103.8 (0.7)	104.8 (0.9)	95.4 (0.5)
4	2	41	117.7 (3.1)	104.4 (0.8)	106.5 (1.1)	96.3 (0.6)
5	1	65	118.4 (2.8)	106.2 (0.8)	109.0 (1.0)	97.7 (0.5)
5	2	43	124.7 (3.1)	106.5 (0.8)	109.0 (1.1)	97.2 (0.6)
6	1	53	122.7 (2.9)	107.8 (0.8)	110.4 (1.0)	98.3 (0.6)
6	2	31	129.8 (3.6)	107.9 (1.0)	111.0 (1.3)	97.5 (0.7)
7	1	37	123.7 (3.3)	107.0 (0.9)	108.9 (1.2)	98.6 (0.7)
7	2	18	135.5 (4.6)	110.1 (1.2)	114.8 (1.7)	98.9 (0.9)
8	1	35	127.2 (3.4)	106.9 (0.9)	110.7 (1.2)	98.8 (0.7)
8	2	24	134.3 (4.0)	107.3 (1.0)	108.3 (1.4)	97.0 (0.8)
9	1	16	123.6 (4.9)	107.6 (1.3)	109.6 (1.8)	100.5 (1.0)
9	2	15	132.0 (5.0)	108.7 (1.3)	113.7 (1.8)	98.3 (1.0)
10	1	24	121.4 (4.1)	106.9 (1.3)	107.1 (1.5)	99.9 (0.8)
10	2	16	134.5 (4.8)	107.8 (1.3)	111.4 (1.8)	98.7 (0.9)
11	1	7	120.5 (11.0)	105.9 (2.7)	111.9 (4.4)	99.9 (2.0)
11	2	8	117.3 (8.5)	106.8 (2.7)	110.5 (3.4)	96.9 (2.0)
12	1	16	117.2 (5.2)	106.4 (1.4)	106.8 (1.9)	99.8 (2.6)
12	2	23	130.1 (4.5)	108.0 (1.2)	112.5 (1.6)	97.2 (1.6)
13	1	5	117.3 (6.8)	107.9 (2.1)	107.2 (2.7)	101.5 (1.6)
13	2	10	138.5 (6.0)	108.6 (1.8)	111.4 (2.4)	97.00 (1.4)
Adults[3]	1	193	123.2 (2.1)	107.8 (0.7)	109.2 (0.8)	100.1 (0.5)
	2	145	132.5 (2.3)	108.3 (0.7)	111.9 (0.9)	97.7 (0.5)

[1] Age in years; [2] Sex: 1 = male, 2 = female; [3] Donkeys 6-13 years of age

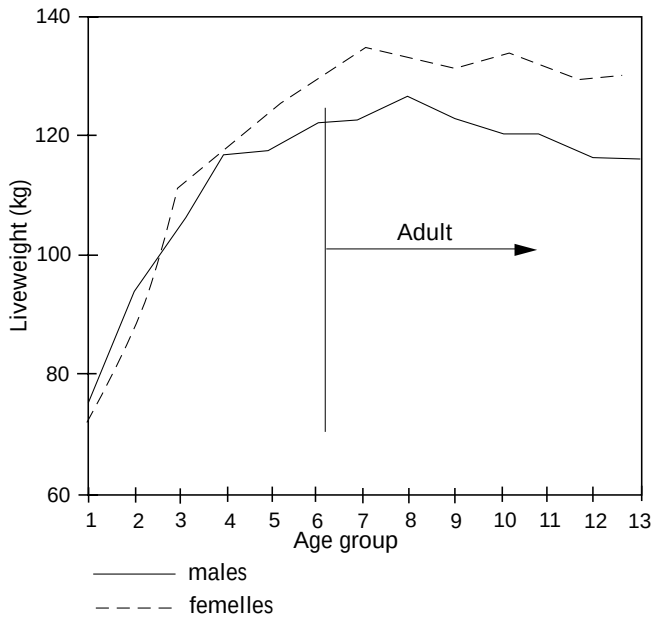

***Figure 3**: Plot of liveweight against age group.*

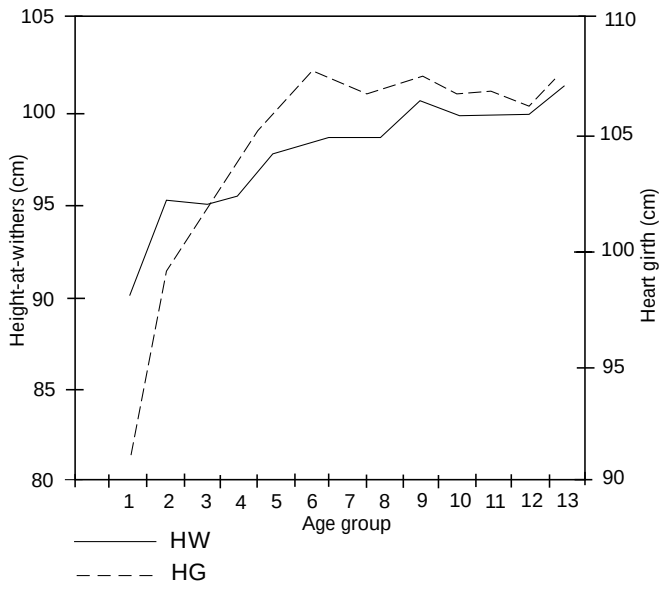

***Figure 4**: Plots of heart girth and height-at-withers against age group for male donkeys.*

Table IV

Estimated liveweight (LW) from heart girth (HG) using model: $LW = HG^{2.826}/4434.7$

HG (cm)	LW (kg)	HG (cm)	LW (kg)
60	24	93	83
61	25	94	85
62	26	95	88
63	27	96	90
64	29	97	93
65	30	98	96
66	31	99	99
67	33	100	101
68	34	101	104
69	36	102	107
70	37	103	110
71	39	104	113
72	40	105	116
73	42	106	120
74	43	107	123
75	45	108	126
76	47	109	129
77	48	110	133
78	50	111	136
79	52	112	140
80	54	113	143
81	56	114	147
82	58	115	151
83	60	116	154
84	62	117	158
85	64	118	162
86	66	119	166
87	68	120	170
88	71	121	174
89	73	122	178
90	75	123	182
91	78	124	186
92	80	125	191

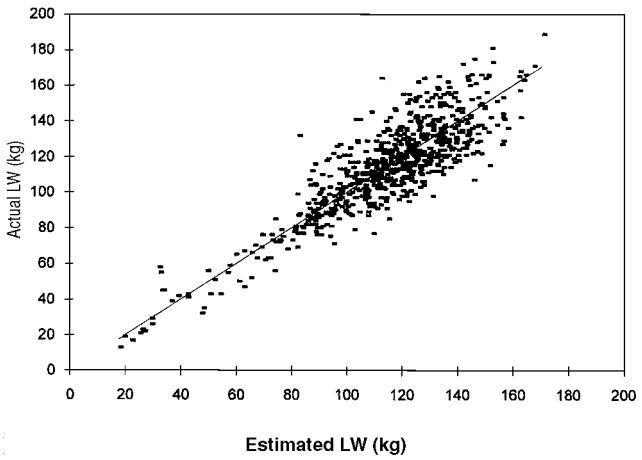

***Figure 5**: Draft donkeys of North Cameroon. Plot of actual liveweight against estimated liveweight:*
$LW = HG^{1.947} \times TL^{0.845}/3834.8$ ($R^2 = 0.86$; $n = 743$).

observations on coat color have been reported by Wilson (13) on the Sudan pack donkey. This may suggest that the Cameroonian donkey could be part of this breed. Estimates for liveweight, heart girth, trunk length and height-at-withers reported by Raveneau and Daveze for the breed (8) are, however, higher than those obtained in the present study. Possible reasons may be that a progressive degeneration in the breed might have taken place in Cameroon. There is also the possibility that ecoclimatic differences might have had an impact on the genotype environmental interaction. Poor management donkey practices in this area might also have had a negative impact on its development and growth.

The significant influence of sex on liveweight may be due to differences in physiological and draft activities. Female donkeys in this region become reproductive at 3 years of age. It would not be surprising that pregnant donkeys were measured during the study given that there was no instrument to detect non visible pregnant donkeys. The weights of the not visibly pregnant donkeys were therefore inflated, causing significant higher weights for female donkeys at 3 years and above. Though donkeys in the region are used for draft activities starting at 3 years of age, maximum draft activities might be reached at a crucial period of 6 years. After this crucial period of draft activities it is unlikely that the quality of feed available for the donkeys is sufficient to meet at the same time extra energy requirements for work and growth and reproduction needs. According to Klaus and Uwe (3), such a work demand will have a measurable effect on energy and possibly nutrient requirements so that animals which are left exclusively to forage for themselves will lose weight.

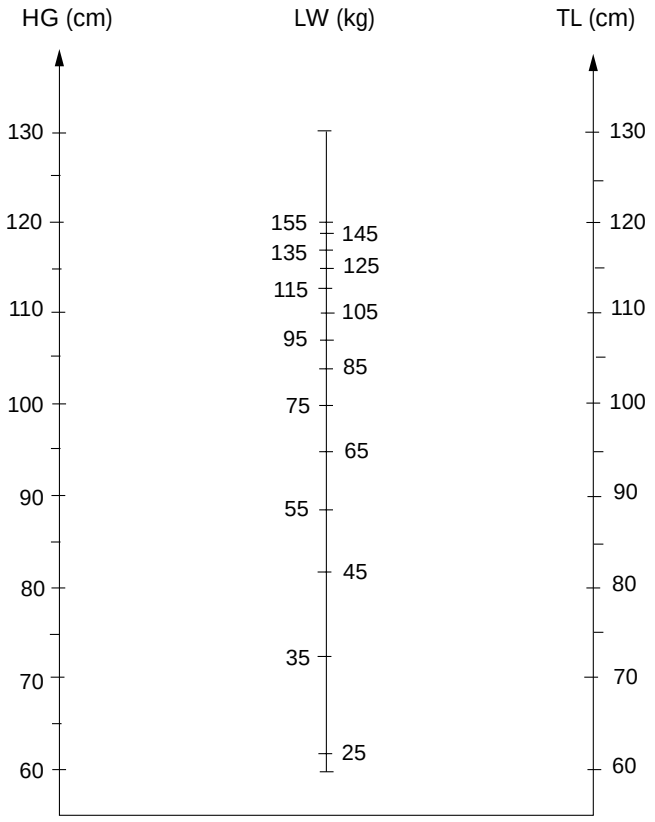

***Figure 6**: Normogram useful in the determination of a donkey liveweight (LW) by simply using a measuring tape to obtain values for heart girth (HG) and trunk length (TL).*

A strong relationship existed between liveweight and heart girth (0.85), suggesting that heart girth is the most variable live measurement which reflects conditions in the donkey. On the other hand, trunk length and height-at-withers are skeletal measurements which are less variable. This strong relationship has also been reported by Pearson and Ouassat (5). Poivey *et al.* (6) working on African cattle also reported heart girth as the most suitable best fit variable for the estimation of animal liveweights. The inclusion of height-at-withers in the equation as a third variable did not modify the prediction accuracy. The use of heart girth and trunk as predictors is practical, as most rural farmers have access to measuring tapes. The use of heart girth and trunk length in the estimation of liveweight compares favorably with the results obtained by Pearson and Ouassat (5) in the Moroccan donkey. However, the advantage of the above equations lies in the fact that they can be extensively used in both sexes for young and older donkeys. They may not, however, be useful for pregnant donkeys.

■ CONCLUSION

Though the light grey coat color predominates in the donkey population of the Sudano-Sahelian region, its impact on liveweight is not significant. When comparing the coat color description of the Cameroonian donkey with that described for other breeds, the Cameroonian breed seems to correspond to *Equus asinus nubicus*. From 1 to 6 years of age there was a steady increase in liveweight in the study population. Thereafter, this pattern became inconsistent. It is likely that the adult age of donkeys in the area begins at 6 years. Female donkeys there are generally heavier than males, especially during the reproductive period. Sex and age are therefore essential factors that affect liveweight and the different linear measurements. These factors must therefore be taken into consideration when evaluating these traits. Heart girth measurements appeared to be the most accurate estimators of liveweight. However, improvement in the R^2 value is obtained by incorporating trunk length to it in a multiple regression equation. The inclusion of height-at-withers as a third variable does not significantly change the R^2 value.

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Résumé

Ebangi A.L., Vall E. Caractérisation phénotypique des ânes de trait dans la zone soudano-sahélienne du Cameroun

Les données sur l'âge, le sexe, la couleur de la robe, le poids vif (PV), le périmètre thoracique (PT), la longueur du tronc (LT) et la hauteur au garrot (HG) ont été collectées sur 743 ânes de la zone soudano-sahélienne du Cameroun. L'âge des ânes s'est étalé de 0 à 13 ans. L'effet de l'âge sur le poids vif, la hauteur au garrot, le périmètre thoracique et la longueur du tronc était très significatif ($p < 0,001$). L'effet de la couleur sur le poids vif et la hauteur au garrot n'était pas significatif ($p > 0,05$). Les ânes mâles étaient généralement plus lourds que les femelles de 0 à 3 ans. Par la suite, les ânesses sont devenues plus lourdes que les mâles ($p < 0,002$). Les poids vifs moyens des femelles et des mâles adultes (âges : 6 à 13 ans) étaient respectivement de 132,5 ± 2,3 et de 123,2 ± 2,1 kg. Ils pouvaient ne pas avoir de conséquences pratiques significatives sur leur capacité de travail car des ânesses en gestation non apparente pouvaient avoir été comprises dans l'étude. Ainsi, des équations de régression communes aux deux sexes ont été établies pour l'estimation du poids vif. Les équations de prédiction du poids vif des ânes dans la région soudano-sahélienne du Cameroun les plus adaptées étaient :

■ $PV = PT^{2,826}/4434,7$ (R^2 ajusté = 0,84) pour une variable qui convient le mieux, avec PV en kilogrammes et PT en centimètres. Quand la longueur du tronc ou la hauteur au garrot était considérée comme variable unique convenant le mieux dans l'équation, les valeurs de R^2 ajusté étaient respectivement de 0,78 et 0,66 ;

■ $PV = PT^{1,947}.LT^{0,845}/3834,8$ (R^2 ajusté = 0,86) pour deux variables, avec LT en centimètres. La prise en compte de la variable HG dans un modèle à trois facteurs n'a pas amélioré significativement la valeur de R^2.

Mots-clés : Ane - Animal de trait - Conformation animale - Mensuration corporelle - Zone soudano-sahélienne - Cameroun.

Resumen

Ebangi A.L., Vall E. Caracterización fenotípica de los burros de tiro en la zona sudano-saheliana de Camerún

Se recolectaron datos sobre la edad, sexo, color, peso vivo (PV), circunferencia torácica (CT), largo del tronco (LT) y altura a la cruz (AC), en 743 burros en la región sudano-saheliana de Camerún. Las edades de los burros variaron de 0 a 13 años. El efecto de la edad sobre el peso vivo, la altura a la cruz, la circunferencia torácica y el largo del tronco fue altamente significativo ($p < 0,001$). El efecto del color sobre el peso vivo y la altura a la cruz no fue significativo ($p > 0,05$). Los burros machos fueron generalmente más pesados que la hembras de 0 a 3 años de edad. Sin embargo, las hembras se tornaron mas pesadas que los machos ($p < 0,002$). El peso vivo promedio de 132,5 ± 2,3 y 123,2 ± 2,1 kg, en hembras y machos de 6 a 13 años de edad respectivamente, pudo no haber tenido implicaciones practicas significativas sobre la capacidad de trabajo de los sexos, dado que hembras con preñeces no evidentes pueden haber sido incluidas en el estudio. Por lo tanto, las ecuaciones de regresión establecidas para la estimación del peso vivo no fueron discriminativas para el género. Por lo consiguiente, las mejores ecuaciones de predicción para el peso vivo de los burros en la región sudano-saheliana fueron:

■ $PV = CT^{2,826}/4434,7$ (ajustado a $R^2 = 0,84$) para la variable mejor habilitado, con PV en kilogramos y CT en centímetros. Cuando se consideró el largo del tronco y la altura a la cruz para la ecuación para mejor habilitado, el valor de ajuste de R^2 fue de 0,78 y 0,66, respectivamente;

■ $PV = CT^{1,947}*LT^{0,845}/3834,8$ (ajustado con $R^2 = 0,86$) para dos variables de mejor habilitado con LT en centímetros. La inclusión de AC como tercer variable en la ecuación no modificó significativamente R^2.

Palabras clave: Asno - Animal de tiro - Conformación animal - Medición del cuerpo - Región sudano-saheliana - Camerún.